Measuring DFT on Steel I-Beams

A nswer
Ray Weaver,
SSPC,
Pittsburgh, PA, U.S.:
SSPC is in the preliminary stages of developing a procedure for measuring the dry film thickness (DFT) of coatings on steel beams.

Section 5.3 of SSPC-PA 2 is the elastic clause that would apply to DFT measurement on steel beams. It states, “Other size areas or number of spot measurements may be specified in the procurement documents as appropriate for the size and shape of the structure to be measured.” SSPC and the American Institute of Steel Construction (AISC) propose to write a specific procedure for steel beams.

The main problem for the painter in coating steel beams is providing the same uniform thickness over high and low vertical surfaces as over horizontal surfaces. On a beam, there are proportionately more edges, which tend to have low DFT, and more inside corners, which tend to have high DFT compared to the center of the flat surfaces. Each painter usually develops a pattern of work for a specific task. Hence, the DFT on the underside of the top flange, for example, may be consistently on the high side or the low side of the target DFT. This type of systematic error is easy to detect and correct. Random errors pose a more difficult problem. Gross errors where the paint is obviously too thin or too thick must be corrected and are beyond the scope of this discussion.

A beam has eight different surfaces as shown in Fig. 1. Any one of these surfaces may have a DFT outside the specified range and, hence, is the DFT. No spot measurement can differ from the specified DFT by more than 20 percent. This stipulation will cause rejection if the dry film on one of the surfaces is too thin or too thick. If some of the eight surfaces are not accessible, take at least five spot measurements with at least one spot on each accessible surface. Repeat for the other two-foot (0.6-meter) length.

For beams between 40 ft (12 m) and 80 ft (24 m) in length, divide the beam into thirds. Choose a two-foot (0.6-meter) length of beam near one end, and randomly select a two-foot (0.6-meter) length from each of the other thirds. Measure the DFT in each two-foot (0.6-meter) length as described above.

For beams over 80 ft (24 m) in length, divide the beam into 40-foot (12-meter) segments. The final segment will be less than 40 ft (12 m) if the total length of the beam is not a whole number of 40-foot (12-meter) increments. Choose a two-foot (0.6-meter) length near one end and a randomly selected two-foot (0.6-meter) length from each beam segment. Measure the DFT in each two-foot (0.6-meter) length as described above.

For batch jobs of many girders, measure the first girder as described above; and then measure the DFT on a random two-foot (0.6-meter) length from each of the other girders. Measure the DFT in each two-foot (0.6-meter) length as described above.

Q uestion
On a steel I-beam, how many dry film thickness (DFT) measurements are required to achieve a meaningful statistical average, and where should they be taken—on the top and bottom of both the upper and lower flanges and on both sides of the web?

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A "laydown" is a group of steel members laid down to be painted in one shift by one painter. For inspection of a laydown of beams or columns, the first step is to make a visual survey to detect areas with obvious defects, such as poor coverage. If the laydown passes the visual inspection, select one piece from among the first pieces painted and measure the DFT as described above. Repeat the procedure for a piece painted near the center of the laydown and one painted near the end of the laydown.

For a laydown of miscellaneous parts, measure the DFT of a part painted near the beginning, the middle, and the end of the laydown. As a minimum, choose one part from among those painted in each two-hour interval. Take a spot measurement on each plane (surface) of the chosen part using a minimum of five spots per part. As always, the average of the spots is the DFT, and no spot shall differ from the specified DFT by more than 20%.

**Answer**

Mark B. Dromgoole, KTA-Tator Australia Pty Ltd, Richmond, Victoria, Australia:

Several excellent standards around the world give guidance for collecting DFT readings on coated substrates. Two that are widely recognized in Australia and Southeast Asia are Australian Standard (AS) 3894.3-1993 (Site Testing of Protective Coatings, Method 3: Determination of Dry Film Thickness) and SSPC-PA 2 (1991, Measurement of Dry Paint Thickness with Magnetic Gages). I will concentrate on the former standard. Because it was based on an early version of SSPC-PA 2, there are many similarities between the two.

I believe that to be of most use, these standards need to be interpreted in a manner appropriate to the task at hand, not necessarily literally. AS 3894.3 suggests devising a project-specific inspection plan detailing the number of readings to be taken, generally per module of surface area for flat surfaces, or per meter of length for structural, piping, or slender articles.

For instance, AS 3894.3 suggests that an appropriate inspection plan for flat surfaces could be 5 readings for each (approximately) 10 sq m (110 sq ft) of painted area. Further, if the article is up to approximately 30 sq m (320 sq ft), each 10-square-meter (110-square-foot) area would be measured. If it is up to 100 sq m (1,100 sq ft), then three 10-square-meter (110-square-foot) areas would be measured at random, and another 10-square-meter (110-square-foot) area for each further 100 sq m (1,100 sq ft).

For example, if a storage tank is to be measured, and if each tank plate is approximately 8 sq m (90 sq ft) in
area, then the project-specific inspection plan may ask for approximately five readings per plate. This number is perfectly acceptable. It is not necessary to follow the standard’s suggestion literally and take 5 readings for each plate and a quarter (to equal the 10 sq m [110 sq ft]).

As to the question of where readings on flat surfaces should be taken, the standard is silent and appropriately so. Otherwise, all effort would go into following the literal guidance and not putting thought and design into devising an inspection plan that is project- or item-specific.

For small surface areas, AS 3894.3 suggests a minimum of three readings per square meter. For pipework, the standard suggests that a number of readings be taken evenly around the circumference. The quantity per meter of length should be appropriate to the pipe diameter. With respect to beams and angles, the standard suggests... “one reading on each flat face less than 300 mm (12 in.) in width, for each lineal metre.”

On the question of where readings should be taken on structural members (such as I beams), the standard is a little more specific. My interpretation of the standard is that on a regular rolled column or beam section, eight readings per lineal meter are suggested—one on each flat face. Thus, there would be one reading on the top outer flange; two on the underside of the top flange (one on either side of where the web joins the flange); one on each side of the web face itself; and three more on the lower flange, exactly as detailed for the upper flange.

Notwithstanding the above guidance, an intelligent inspection plan should call for an appropriate and achievable frequency of readings. The frequency would depend on the access available, the configuration of the coated item, and a pattern of inspection points that has proven acceptable on projects that used the same or similar coatings, the same application methods, and workers of the same skill level.

Therefore, the inspector is charged with devising an appropriate plan that takes into account the frequency and locations of readings and then uses the standard’s well-reasoned statistical evaluation process to define acceptance.

Answer
Brian F. Connell,
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The following factors may influence the number of readings to be taken:
• location of the I-beam (i.e.,...
whether it is in a shop or part of an on-site construction);
• the size and shape, dimensions, and configuration of the I-beam and (if known) its accessibility (particularly during preparation and painting);
• the condition of the substrate before coating, the number and types of coats applied, and the method of application;
• the choice of instrument being used and the inspector’s confidence in its accuracy;
• applicable client specifications, appropriate standards, and specific material manufacturer requirements; and
• time constraints relevant to the coating’s state of cure and the actual task of measuring the dry film thickness.

Consider the following four scenarios.

1) An I-beam with a 500-millimeter (20-inch) web depth and 150-millimeter (6-inch) top and bottom flanges (30-millimeter [1.2-inch] flange edges) and a length of 5 m (16 ft) has been blast cleaned using recycled G24 chilled iron/steel grit to a profile of 40 to 75 micrometers (1.6 to 3 mils) and coated with a prefabrication primer by automatic spray.

2) An identical I-beam blast cleaned with the same medium and to the same profile has been placed on support stands with a ground clearance of less than 250 mm (10 in.) and coated by means of a roller and brush.

3) An identical I-beam coated with a three-coat system in a shop by manually operated airless spray requires a final DFT determination by an independent inspector before dispatch to the site. Defects would be spotted and repaired before the job left the shop.

4) Final inspection is required for an I-beam that has been prepared and coated with a three-coat system in a shop by means of manually operated airless spray while under full-time inspection. (Wet film and dry film thickness measurements of the primer and intermediate coats and wet film thickness of the topcoat have been recorded.)

It is not necessarily appropriate to adopt statistical average DFT determinations in some of the above instances, especially in the case of example 2 because of the nature of the coating method used there and the variable thickness values likely to be obtained. The primary concern with using a statistical average DFT for example 2 is the danger of ignoring the probability that some of the spot readings are likely to be below the recommended minimum DFT requirements necessary to provide adequate corrosion protection.

Nor are statistical average DFTs needed in the case of example 1.
Once the spray gun parameters have been set, the application is expected to be highly uniform. Periodic DFT measurements would be needed to verify that process control parameters (e.g., coating feed rate and temperature) are maintained.

Assuming there are no specified requirements, no doubts about the visual appearance or volume solids content of the materials used, and no question that the DFT gauge has been correctly calibrated and checked for accuracy, an inspector checking example 4 would need to perform no more than seven sets of three spot readings (a total of 21) per side for approximately each meter (three feet) of length of the I-beam. For a 5-meter (16-foot) beam, this would be a total of 210 readings. This would be enough to provide a meaningful statistical average and assurance that the specified film thickness has been achieved.

These sets of three spot readings can be carried out at random, alternating between the various elements and the two sides of the I-beam, such as in the following example.

Side one, first meter (three feet):
- edge of top flange—one set of readings
- underside of top flange—one set of readings
- web area—two sets of readings
- top of bottom flange—one set of readings
- edge of bottom flange—nil
- underside (soffit)—two sets of readings

Side two, first meter (three feet):
- edge of top flange—nil
- underside of top flange—two sets of readings
- web area—three sets of readings
- top of bottom flange—one set of readings
- edge of bottom flange—one set of readings

Provided the values being obtained on the various elements within the specific section (meter length) are within the specified thickness values required, no additional readings would be necessary. However, if the values obtained were below that specified, additional sets of readings on the specific element(s) should be done to confirm whether there is non-compliance and if remedial treatment is required.